



NATIONAL STEEL AND SHIPBUILDING COMPANY

LEAPFROG TECHNOLOGY TO
STANDARDIZE EQUIPMENT
AND SYSTEM INSTALLATIONS

UNIVERSITY OF NEW ORLEANS SUBCONTRACT

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SECTION NO. 3 —DESIGN CRITERIA AND ATTRIBUTES FOR REDUCING COST

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3 DESIGN CRITERIA AND ATTRIBUTES FOR REDUCING COST

DEVELOP DESIGN ATTRIBUTES FOR EQUIPMENT INSTALLATIONS

This sub-task report provides the design criteria including producibility features, production and installation techniques for equipment installations, for cost reduction and reduced labor content. These key attributes will facilitate weight and cost reduction through development of standards for foundation design, fabrication and installation.

PRODUCIBILITY ATTRIBUTES FOR EQUIPMENT INSTALLATIONS

1. The Foundations should be based on achieving the most producible structural designs while meeting the requirements of the specifications. Since foundation design normally takes place after the functional arrangement of the equipment has been integrated into the ship design with supporting ships systems, there may be only limited geometrical flexibility remaining to achieve producible foundation designs. However, some accommodation by systems or equipment arrangements may be possible and should be pursued in order to achieve optimum producible foundations.
2. Develop designs which require a minimum number of operations per piece.
3. Make foundations rectilinear in configuration.
4. Foundation headers on opposite sides of bulkhead or deck should be avoided where possible. Production scheduling usually causes headers to be added after the basic structure is finished.
5. Provide sufficient access to facilitate installation and welding.
6. Lift foundation off structure
 - Reduces weld length/volume
 - Simplifies fitting in way of distorted deck and bulkhead plating
 - Reduces the possibility of "locked-in" stresses, and in some cases reduces hard spots
 - Flexible foundations decouple the equipment from the ship reducing the shock load on the equipment
7. Simplify foundation designs/improve fitting
 - Reduce manufacturing aids/lofting effort
 - Reduce number of pieces required
 - Substitute studs for welded plate foundations
 - Establish quality standards that are consistent with product functions
 - Eliminate unnecessary bolt chocks
8. The minimum use of under-deck and far side headers; the benefit:
 - Results in significant weld and weight reduction

- Eliminates/reduces lofting of headers and fitting problems associated with full depth headers
 - Eliminates pre-outfitting and planning to install headers with sub-assemblies
9. Develop simple attachments, and mechanical fastening techniques.
10. Land foundation structures on soft plating, with minimum or no back-up structures provided vibration criteria are met.
11. By emphasizing producible frame and truss type equipment installations and installation configurations of minimum scantling thickness; the benefit:
- Reduce weld size/passess
 - Elimination/reduction of prepared edges
12. Integrate Equipment installations with hull construction. The methods used to achieve this should be intelligently implemented so that the performance and maintenance of the supported equipment is not compromised with.
13. Simplify hull equipment items
- Redesign top and bottom connections on bins, racks, storage cabinets and furniture support items
14. By the minimum use of bolt chocks and brackets, having the benefit of:
- Minimizing cutting, handling, fitting, and welding small pieces
15. By the use of stud welding to the maximum extent possible including a unique approach using mounting plates installed with studs.
16. By utilizing "method mounting" standard installation techniques for lightweight equipment; the benefit:
- Significantly reduces engineering analysis and construction time

FABRICATION AND INSTALLATION ATTRIBUTES

1. In general shapes, especially angle bar, produce the least expensive construction.
2. In some cases combining flanged plates and shapes may be less expensive.
3. In high weight equipment foundations weldments are approx. 60% more expensive than shapes. Further, in case of light weight foundations weldments are approx. 43% more expensive than shapes.
4. Weldments and flanged plate construction tend to be 7% to 10% heavier than shape construction.
5. Do not use a flanged plate to replace a standard shape. Consider flanged plates to replace weldments. Weldments may be used where shapes and/or flanged plates are impracticable.
6. Use simple attachments and mechanical fastening techniques, where applicable.
7. Replace welded support fabricated from pipe with a double ended shot stud, fabrication and weld of length of pipe is eliminated. Electrician is enabled to install foundation, since a shot stud is used rather than a welded foundation, pipe fitting trade is eliminated from process, fitting and welding trades are eliminated from installation process. Stud welding saves fitting and welding time.

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8. Replaced angle and F.B. foundation with 4 threaded shoulder studs. Fabrication, fitting and welding of foundation are eliminated. Electricians can install foundation, eliminating the requirement for several trades to complete each foundation. Templating time when studs are shot is offset by templating and drilling time at time of equipment installation. Blast, paint, and insulation in way of studs is facilitated.

COST SAVING AND LABOR REDUCTION ATTRIBUTES

- Develop standard foundations for a variety of equipment
- Reduce welding
- Reduce material
- Reduced fabrication / fit-up
- Reduce installation time
- Develop simplified attachment techniques:
 - ✓ Reduces time for installation of foundations
 - ✓ Paves the way to install equipment and systems with their foundations
 - ✓ Reduces sub-assembly construction time on critical path
- Lighter weight deck backup pads are used which are easier to fabricate and install. Coping of angle in way of pad is eliminated.
- Lighter weld is used, decreasing weld time
- Snipe size is reduced, allowing a single continuous weld on each side of the chock to be used. Weld wrap around the chock at each side of the snipe opening is eliminated.
- Delete backup pads, save fabrication, fit up and weld time.
- Delete angle stiffening chocks, save fabrication, fit up, and weld time.
- Lifting angle off of deck or bulkhead
 - ✓ Deleted cope and pad at ends of angle, saving pad fabrication and installation, saving coping of angle.
 - ✓ Eliminate welding of angle to deck or bulkhead. Raised angle allows for complete painting without requiring complete seal welding. Fit up to irregular surface is simplified since only the chocks need be trimmed at installation.
- Relocate chock from bosom of angle to heel
 - ✓ Eliminates trimming to fit between flange and deck or bulkhead plate
 - ✓ Decreases welding by 1/3
- Delete chock, reduces material and fabrication, installation and weld time
- Deleted angle header, eliminates fabrication of header, fit and weld
- Extend chock past flange of angle, eliminate snipe on backside of chock
- Reduce thickness of pad or chock, reduces fabrication time, reduces weld required
- Replace flat bar attachment with chocks.

DEVELOP DESIGN ATTRIBUTES FOR DISTRIBUTIVE SYSTEM INSTALLATIONS

Under this task we have identified key design attributes which will reduce cost and cycle time. The design attributes and criteria for system installations were evaluated to address the Design for Manufacturing and Assembly (DFMA) concept. These attributes were further evaluated from actual manufacturing and installation aspects, where shipyard savings are significant. Information from NASCCO, Avondale, St. John Shipbuilding, KHI, and IHI standards were used to establish some of the cost saving attributes. Standard system installation techniques and methods were incorporated to establish these attributes. Vendor furnished information from TRW, RT&D, SAMTAN and Progressive Fastening Inc. providing standard methods of installation using COTS products were also identified and incorporated. Design methodologies to address these attributes for cost reduction and enhanced producibility were also devised, which will be later incorporated into the standards.

The design attributes for cost reduction, easy fabrication and installation are categorized into General Attributes and Individual Attributes. The General Attributes describe the features which potentially can be incorporated in to the installations for various types of system runs. The Individual Attributes demonstrate cost-saving and producibility features specific to that installation type.

GENERAL ATTRIBUTES

ATTRIBUTES	DESCRIPTION OF SAVINGS AND PRODUCIBILITY
AUTOMATED HANGER SELECTION	DEVELOPING A COMPUTERIZED SYSTEM (DFMA) THAT COULD PROVIDE A HANGER SELECTION GIVEN A MINIMUM NUMBER OF VARIABLE INPUTS (CABLE WEIGHT, SPACING, ETC.) WOULD BE VERY COST EFFECTIVE IN THE LONG RUN.
MINIMIZE WELDING	IN ALL CASES, THE MINIMUM REQUIRED WELD LENGTH AND THICKNESS SHOULD BE USED. THIS PRODUCIBILITY MEASURE COULD SAVE LABOR COST IF SIGNIFICANT NUMBERS OF HANGERS ARE INSTALLED.
SHOP WELDING	WHEREVER POSSIBLE WELDING SHOULD BE DONE IN THE SHOP RATHER THAN ON THE SHIP AS SHOP WELDING IS LESS LABOR INTENSIVE AND THEREFORE COST EFFECTIVE.
SHOP ASSEMBLY	AS MUCH HANGER ASSEMBLY AS POSSIBLE SHOULD TAKE PLACE IN THE SHOP TO SAVE LABOR ON THE SHIP.
METHOD MOUNTS	METHOD MOUNTS (STUDS, SPOOLS, AND FASTENERS) CAN BE CHEAPER AND LESS LABOR INTENSIVE THAN WELDED ANGLES.
HANGER DESIGN IMPROVEMENTS	AN AUTOMATED MACHINE CAPABLE OF BENDING SHAPES INTO THE PROPER HANGER CONFIGURATION MAY PROVE TO SAVE COSTS BY REDUCING CUTTING AND WELDING OF HANGERS.
ADJUSTABLE LENGTH HANGERS	PROVIDING AN ADJUSTABLE LENGTH FEATURE WOULD ALLOW MANY TYPES OF HANGERS TO BE STANDARDIZED AND MASS PRODUCED OR PURCHASED CHEAPLY, AS ONE HANGER COULD BE USED IN MANY SITUATIONS. A HANGER CAPABLE OF ATHWARTSHIP ADJUSTMENT AS WELL WOULD BE EVEN BETTER. THESE ADJUSTMENT FEATURE ELIMINATES THE NEED FOR TRIMMING OF LEGS. A SINGLE FILLET WELD WOULD BE THE ONLY LABOR NECESSARY.
VERSATILE DOWN-COMER DESIGN	DOWN-COMERS WHICH CAN SUPPORT SYSTEM RUNS OF ORTHOGONAL DIRECTIONS HELP MINIMIZE THE NUMBER OF HANGERS. PROGRESSIVE FASTENING DOWN-COMERS OFFER THIS.
ADJUSTABLE PIPE SLEEVE	SYSTEM RUN SUPPORTS AND STOOLS HAVING AN ADJUSTABLE PIPE.
STAND-OFF / LEGS	SLEEVE AS PART OF THEIR LEGS OR STANDS-OFF WILL ELIMINATE FIT-UP AND CUT TO SUIT PROBLEMS AND ALSO EASE THE PAINTING.
BRACE DESIGN	BRACE DESIGN SHOULD BE SUCH THAT THEY CAN BE MECHANICALLY FASTENED AT BOTH ENDS, WITH MINIMUM OR NO CUTTING, FIT-UP AND WELDING. RT&D BRACE DESIGN OFFERS THIS.
ALTERNATIVE BRACE DESIGN	BRACES CAN BE MADE UP OF PIPES OF STANDARD LENGTH AND SIZE, WITH THREADED

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ATTRIBUTES	DESCRIPTION OF SAVINGS AND PRODUCIBILITY
	ENDS WITH LOCK-NUTS AND HAVE TURN-BUCKLE CONNECTIONS AT BOTH ENDS. THIS WILL ALLOW THE SAME STANDARD BRACE SIZE TO BE USED AT VARIOUS LENGTHS AND ORIENTATIONS.
LAP WELDS	WHERE POSSIBLE, USE A LAP WELD IN LIEU OF A SHAPED WELD. THIS CREATES AN EASIER FABRICATION PROCESS AND ALLOWS FOR ADJUSTMENT.
RACKS FOR MULTIPLE SYSTEMS	THIS ALLOWS RACKS TO BE BUILT IN PARALLEL WITH THE BLOCK BEING OUTFITTED, THUS REDUCING OVERALL CYCLE TIME.
USE SHIP STRUCTURE TO LOCATE RACKS	USE EXISTING WEBS AND BEAMS AS HANGER LOCATIONS. THIS MINIMIZES BOTH LAYOUT AND INSTALLATION TIME. IN ADDITION, MULTIPLE HANGERS CAN BE USED AS TEMPLATES FOR LOCATIONS OF WELD STUDS.
SYSTEM RUN DIRECTION	SYSTEMS SHOULD BE RUN FORE AND AFT OR ATWARTSHIP TO UTILIZE SHIP STRUCTURE AND ENABLE HANGER INSTALLATION TO BE ROUTINE AND THEREBY COST EFFECTIVE.
VENDOR PURCHASE	WHEREVER PRACTICAL, PURCHASE HANGERS (DOWNCOMERS, CROSSTIERS, ETC.) FROM AN OUTSIDE VENDOR AND ASSEMBLE IN HOUSE. THIS SAVES FABRICATION TIME.
BANDING CABLES	GROUPS OF CABLES HEADING THE SAME WAY SHOULD BE Banded TOGETHER TO SAVE LAYOUT TIME.
UNDESIRED LOCATIONS	<p>CABLES SHALL BE INSTALLED TO AVOID UNDESIRED LOCATIONS SUCH AS:</p> <ul style="list-style-type: none"> ▪ EXCESSIVE MOISTURE AREAS ▪ NEAR MAGNETIC COMPASS ▪ IN LOCATIONS EXPOSING THE CABLE TO MECHANICAL DAMAGE ▪ IN LOCATIONS CREATING AN INTERFERENCE WITH MACHINERY REMOVAL ▪ IN AREAS THAT ARE HAZARDOUS OWING TO A FLAMMABLE OR EXPLOSIVE ATMOSPHERE IN ACCESSIBLE SPACES
EXCESSIVE HEAT AREAS	THREADED PARTS EXPOSED TO THE WEATHER, SEA WATER, OR MOISTURE SHALL BE COATED WITH AN ANTI-SEIZE COMPOUND.

METHOD 1

U-BOLT ASSEMBLY W/ STAND-OFF OR STOOL

- USE LAP WELD THAN FIT-UP TO ATTACH LEGS TO THE SUPPORT PLATE/ANGLE
- USE PIPE W/ SLEEVE INSTEAD OF ANGLE FOR LEGS, GIVES HEIGHT ADJUSTMENT FLEXIBILITY AND EASE OF PAINTING

METHOD 2

CLAMP HANGERS

- REPLACE WELD ATTACHMENT AT SHIP STRUCTURE WITH STUD MOUNTING
- USE U-BOLTS IN PLACE OF FABRICATED CLAMPS WHERE POSSIBLE
- USE ADJUSTABLE BRACING WITH MECHANICAL FASTENERS THAN WELDED FIXED LENGTH BRACE

CLAMP AND CHANNEL HANGERS

- USE STANDARD CHANNEL SIZES
- USE ONE LONG CHANNEL TO ACCOMMODATE MULTIPLE PIPES, THAN USE SHORT PIECES FOR EACH PIPE.

METHOD 3

FULL CAP /BAND HANGERS

- USE U-BOLTS IN PLACE OF FULL CAP WHERE POSSIBLE

FULL CAP /BAND HANGERS W/ STAND-OFF OR STOOL

- SEE METHOD 1 ATTRIBUTES

METHOD 4

SINGLE LEG "L" BAND HANGER

- USE COMMERCIALLY AVAILABLE L-LEG THAN FABRICATE

METHOD 5

RTD STUD HANGERS

- REDUCE THE NUMBER OF PIECES FOR THE BRACE
- FASTEN THE BRACE DIRECTLY TO THE DOWN-COMER W/O ANY CLAMP

NELSON TYPE HANGERS

- REPLACE TWIST KEY WITH TIE ROD

METHOD 6

RESILIENT HANGERS

- REDUCE THE NUMBER OF PIECES

- DEVICE AN ALTERNATIVE TO THE DOG-NIPPLE ASSEMBLY

METHOD 7

RUBBER BLOCK HANGERS

- Replace Down-comer Angle with Pipe, where possible

ELECTRICAL SYSTEMS

INDIVIDUAL ATTRIBUTES

METHOD 1

NELSON STUD CABLE SUPPORT

- SEVERAL STANDARD STUD LENGTHS WITH THE SAME DIAMETER
- SEPARATE CABLE STRAP WHICH FITS ALL STUD LENGTHS
- USE THREADING TO FINE TUNE VERTICAL POSITION

CH TYPE CABLEWAY

- STANDARD CHANNEL SECTION
- FULL SPAN OF CHANNEL MAY NOT BE NECESSARY
- ATTACH FLATBAR TO WEB (NOT FLANGE) WITH LAP WELD TO ALLOW HEIGHT ADJUSTMENT

L TYPE CABLEWAY

- STANDARD FITTING PIECE SIZES
- USE LAP WELD TO ADJUST HEIGHT
- STANDARD ANGLE SIZES
- CONTINUOUS ANGLE RUNS MAY NOT BE NECESSARY

HANGER TYPE CABLEWAY SF, SH

- STANDARD HANGER SIZE
- STUD WELD IF POSSIBLE

METHOD 2

TYPE A/C T-GRID CEILINGS

- ASSEMBLE FRAMEWORKS IN SHOP OR PURCHASE
- ATTACH NELSON CLAMP IN SHOP WITH STUD WELD
- ASSEMBLY SHOULD BE HEIGHT ADJUSTABLE (THREADING ON CLAMP)

METHOD 3

HONEYCOMB BULKHEAD HANGER

- USE WELD INSTEAD OF RIVET

- STANDARD BRACKET SIZE

METHOD 4

SECURING LOCAL CABLES ON SHEATHING

- SINGLE CABLE CLAMP SIZE

METHOD 5

TUBULAR HANGERS

- ASSEMBLE STUD AND T-BAR IN SHOP
- STANDARD T-BAR SECTION
- STANDARD STUD DIAMETER WITH VARIABLE LENGTHS FOR HEIGHT ADJUSTMENT

METHOD 6

SUPPORTING T-BAR HANGERS ON BULKHEADS USING CHANNEL

- ATTACH T-BARS TO CHANNEL IN SHOP
- STANDARD CHANNEL SECTION
- USE LAP WELDS

METHOD 7

SUPPORTING CABLES RUNNING ON CEILING FURRING

- STANDARD JAMMING BARS TO FIT DIFFERENT FURRING SIZES
- SEEK ALTERNATE ATTACHMENT METHOD AS JAMMING BAR WELD LOOKS LABOR INTENSIVE. PERHAPS WELDING THE STUD DIRECTLY TO THE FURRING OR PLACING THE JAMMING BAR ON TOP OF THE FURRING WOULD BE EASIER.
- USE THREADING AS HEIGHT ADJUSTMENT
- USE STANDARD T-BAR SECTION

METHOD 8

CABLES MOUNTED ON PIPE SUPPORTS

- STANDARD WIDTH STRAPS

METHOD 9

CROSSTIERS ON CHANNEL DOWNCOMER

- BUY STANDARD CHANNELS AND CROSSTIERS TO ASSEMBLE IN SHOP
- ADEQUATE HOLES FOR HEIGHT ADJUSTMENT
- CONSIDER ADAPTER BRACKET FOR EASE OF ATTACHMENT AND REMOVAL
- STANDARD WIDTH STRAPS
- USE SHIP STRUCTURE TO LOCATE AND THEN USE LAP WELD

METHOD 10

SUPPORTING VERTICAL TIERS OF CABLE INDEPENDENT OF SHIPS STRUCTURE WITH METHOD 9 HANGERS

- STANDARD CHANNEL SECTIONS FOR VERTICAL PIECE
- ASSEMBLE CHANNEL DOWNCOMERS AND CROSSTIERS IN SHOP
- USE STANDARD ASSEMBLY PADS

METHOD 11

TRAPEZE TYPE CROSS-TIERS AND CABLE TROUGHS

- BUY STANDARD CHANNELS AND CROSS-TIERS TO ASSEMBLE IN SHOP
- ADEQUATE HOLES FOR HEIGHT ADJUSTMENT
- CONSIDER ADAPTER BRACKET FOR EASE OF ATTACHMENT AND REMOVAL
- USE STANDARD WIDTH CABLE STRAPS
- USE SHIP STRUCTURE TO LOCATE HANGERS AND USE LAP WELDS

TRAPEZE WITH PIPE

- STANDARD FITTING PIECES, LAP WELD TO ADJUST HEIGHT
- ATTACH TO WEB RATHER THAN FLANGE
- STANDARD PIPE DIAMETERS
- STANDARD ANGLE SIZES (SECTION AND LENGTH)
- STANDARD WIDTH CABLE STRAPS
- USE SHIP STRUCTURE TO LOCATE HANGERS AND USE LAP WELDS

METHOD 12

SUPPORTING CABLES IN DECKS AND BULKHEADS WHERE WIREWAY SPACE IS LIMITED

- STANDARD CHANNEL SECTION
- TACK WELD INSTEAD OF FULL WELD
- USE FLATBAR TO LIFTOFF TO ADJUST HEIGHT
- STANDARD WIDTH CABLE STRAPS

METHOD 13

SUPPORTING CABLES WITH PORTABLE FLATBAR U-BRACKET

- STANDARD FLATBAR SIDE BRACKETS
- STANDARD WIDTH CABLE STRAPS
- SINGLE BOLT SIZE
- USE HOLE POSITION TO GOVERN HEIGHT ADJUSTMENT

VENTILATION / DUCTING SYSTEMS

INDIVIDUAL PARAMETERS

METHOD 1

ANGLE / FLAT BAR DOWN-COMER HANGERS & ANGLE / FLAT BAR DOWN-COMER W/ CLAMPS
HANGERS

- FOR DOWN-COMERS USE STUD MOUNTING IN PLACE OF WELDING TO THE SHIP STRUCTURE
- USE DOWN-COMERS WITH ADJUSTABLE LENGTH FEATURE - SEE RT&D TYPE DOWN-COMERS

METHOD 2

RTD DUCT HANGERS

- SEE ATTRIBUTES FOR RTD STUD HANGERS IN PIPING SECTION

METHOD 3

RESILIENT DUCT HANGERS

- USE COMMERCIALY AVAILABLE CLAMPS
- USE FLEXIBLE LENGTH DOWN-COMERS